

1 2. (Currently Amended) The ~~computer implemented~~ method of claim 1 wherein the
2 integer program comprises the performance constraint and an objective of minimizing
3 a cost.

1 3. (Currently Amended) The ~~computer implemented~~ method of claim 1 wherein the
2 integer program models a data placement problem.

1 4. (Currently Amended) The ~~computer implemented~~ method of claim 3 wherein the
2 data placement problem seeks to minimize a cost of placing the data objects onto the
3 nodes of athe distributed storage system while meeting athe performance requirement
4 for athe workload.

1 5. (Currently Amended) The ~~computer implemented~~ method of claim 1 wherein the
2 step of rounding up the first binary variable within the first subset further comprises
3 calculating the cost penalty and the performance reward.

1 6. (Currently Amended) The ~~computer implemented~~ method of claim 5 wherein the
2 step of rounding down the one or more second binary variables within the second
3 subset further comprises calculating the performance reward.

1 7. (Currently Amended) The ~~computer implemented~~ method of claim 6 wherein the
2 step of rounding down the third binary variable within the second subset further
3 comprises calculating the cost reward.

1 8. (Currently Amended) A ~~computer implemented~~ method of determining bounds
2 for a minimum cost comprising the steps of:
3 solving an integer program using a relaxation of binary variables to
4 determine a lower bound for the minimum cost, the relaxation allowing the
5 binary variables to take values over the range of zero to one, a first subset of
6 the binary variables comprising the binary variables having values between

7 zero and one, the integer program modeling a data placement problem which
 8 seeks to minimize a cost of placing data objects onto nodes of a distributed
 9 storage system while meeting a performance requirement for a workload;
 10 until no binary variables remain in the first subset, iteratively performing
 11 the steps of:
 12 calculating a cost penalty and a performance reward for each of the
 13 binary variables in the first subset;
 14 rounding up a first binary variable having a lowest ratio of the cost
 15 penalty to the performance reward;
 16 until no binary variables remain in a second subset, iteratively
 17 performing the steps of:
 18 determining the binary variables in the first subset that may
 19 be rounded down without violating the performance
 20 requirement, thereby forming the second subset;
 21 calculating a cost reward and the performance reward for
 22 each of the binary variables in the second subset;
 23 rounding down one or more second binary variables in the
 24 second subset having a zero performance reward;
 25 rounding down a third binary variable in the second subset
 26 corresponding to a highest ratio of a cost reward to the
 27 performance reward if none of the binary variables in the
 28 second subset have the zero performance reward; and
 29 determining an upper bound for the minimum cost according to the binary
 30 variables having binary values; and
 31 placing the data objects onto the nodes of the distributed storage system
 32 using a data placement heuristic selected in accordance with the determined
 33 lower and upper bounds.

- 1 9. (Currently Amended) The ~~computer implemented~~ method of claim 8 wherein the
- 2 integer program further comprises a storage constraint.

1 10. (Currently Amended) The ~~computer-implemented~~ method of claim 9 wherein the
2 step of determining the upper bound for the minimum cost further comprises the steps
3 of:

4 determining a particular node which uses a maximum amount of storage
5 within any evaluation interval; and
6 allocating the maximum amount of storage on all nodes for all evaluation
7 intervals.

1 11. (Currently Amended) The ~~computer-implemented~~ method of claim 9 wherein the
2 step of determining the upper bound for the minimum cost further comprises the steps
3 of:

4 determining a maximum amount of storage for each node within any
5 evaluation interval; and
6 allocating the maximum amount of storage on each node for all evaluation
7 intervals.

1 12. (Currently Amended) The ~~computer-implemented~~ method of claim 8 wherein the
2 integer program further comprises a replica constraint.

1 13. (Currently Amended) The ~~computer-implemented~~ method of claim 12 wherein the
2 step of determining the upper bound for the minimum cost further comprises the steps
3 of:

4 determining a maximum number of replicas for any data object within any
5 evaluation interval; and
6 placing the maximum number of replicas for all data objects for all
7 evaluation intervals.

1 14. (Currently Amended) The ~~computer-implemented~~ method of claim 12 wherein the
2 step of determining the upper bound for the minimum cost further comprises the steps
3 of:

4 determining a maximum number of replicas for each data object within

any evaluation interval; and
 placing the maximum number of replicas for each data object for all
 evaluation intervals.

15. (Original) A computer readable memory comprising computer code for
 implementing a method of determining bounds for a minimum cost, the method of
 determining the bounds for the minimum cost comprising the steps of:
 solving an integer program using a relaxation of binary variables to
 determine a lower bound for the minimum cost, the integer program
 comprising a performance constraint and an objective of minimizing a cost,
 the binary variables having values between zero and one comprising a first
 subset;
 for the binary variables within the first subset and until no binary variables
 remain in the first subset, iteratively performing the steps of:
 rounding up a first binary variable having a lowest ratio of a cost
 penalty to a performance reward; and
 until no binary variables remain in a second subset, iteratively
 performing the steps of:
 determining the binary variables in the first subset that may
 be rounded down without violating the performance constraint,
 thereby forming the second subset;
 rounding down one or more second binary variables in the
 second subset having a zero performance reward; and
 rounding down a third binary variable in the second subset
 having a highest ratio of a cost reward to the performance
 reward if none of the binary variables in the second subset have
 the zero performance reward; and
 determining an upper bound for the minimum cost according to the binary
 variables having binary values.

16. (Original) The computer readable memory of claim 15 wherein the integer

2 program models a data placement problem.

1 17. (Previously Presented) The computer readable memory of claim 16 wherein the
2 data placement problem seeks to minimize a cost of placing data objects onto nodes
3 of a distributed storage system while meeting a performance requirement for a
4 workload.

1 18. (Previously Presented) The computer readable memory of claim 15 wherein the
2 step of rounding up the first binary variable within the first subset further comprises
3 calculating the cost penalty and the performance reward.

1 19. (Previously Presented) The computer readable memory of claim 18 wherein the
2 step of rounding down the one or more second binary variables within the second
3 subset further comprises calculating the performance reward.

1 20. (Previously Presented) The computer readable memory of claim 19 wherein the
2 step of rounding down the third binary variable within the second subset further
3 comprises calculating the cost reward.

1 21. (Original) A computer readable memory comprising computer code for
2 implementing a method of determining bounds for a minimum cost, the method of
3 determining the bounds for the minimum cost comprising the steps of:

4 solving an integer program using a relaxation of binary variables to
5 determine a lower bound for the minimum cost, the relaxation allowing the
6 binary variables to take values over the range of zero to one, a first subset of
7 the binary variables comprising the binary variables having values between
8 zero and one, the integer program modeling a data placement problem which
9 seeks to minimize a cost of placing data objects onto nodes of a distributed
10 storage system while meeting a performance requirement for a workload;
11 until no binary variables remain in the first subset, iteratively performing
12 the steps of:

calculating a cost penalty and a performance reward for each of the
 binary variables in first the subset;
 rounding up a first binary variable having a lowest ratio of the cost
 penalty to the performance reward;
 until no binary variables remain in a second subset, iteratively
 performing the steps of:
 determining the binary variables in the first subset that may
 be rounded down without violating the performance
 requirement, thereby forming the second subset;
 calculating a cost reward and the performance reward for
 each of the binary variables in the second subset;
 rounding down one or more second binary variables in the
 second subset having a zero performance reward;
 rounding down a third binary variable in the second subset
 corresponding to a highest ratio of a cost reward to the
 performance reward if none of the binary variables in the
 second subset have the zero performance reward; and
 determining an upper bound for the minimum cost according to the binary
 variables having binary values.

22. (Original) The computer readable memory of claim 21 wherein the integer
 program further comprises a storage constraint.

23. (Original) The computer readable memory of claim 22 wherein the step of
 determining the upper bound for the minimum cost further comprises the steps of:
 determining a particular node which uses a maximum amount of storage
 within any evaluation interval; and
 allocating the maximum amount of storage on all nodes for all evaluation
 intervals.

24. (Original) The computer readable memory of claim 22 wherein the step of

2 determining the upper bound for the minimum cost further comprises the steps of:
3 determining a maximum amount of storage for each node within any
4 evaluation interval; and
5 allocating the maximum amount of storage on each node for all evaluation
6 intervals.

1 25. (Original) The computer readable memory of claim 21 wherein the integer
2 program further comprises a replica constraint.

1 26. (Original) The computer readable memory of claim 25 wherein the step of
2 determining the upper bound for the minimum cost further comprises the steps of;
3 determining a maximum number of replicas for any data object within any
4 evaluation interval; and
5 placing the maximum number of replicas for all data objects for all
6 evaluation intervals.

1 27. (Original) The computer readable memory of claim 25 wherein the step of
2 determining the upper bound for the minimum cost further comprises the steps of;
3 determining a maximum number of replicas for each data object within
4 any evaluation interval; and
5 placing the maximum number of replicas for each data object for all
6 evaluation intervals.